7. Groundwater Module

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Groundwater is generally defined as all subsurface water that is part of the saturated zone of an aquifer system. The Groundwater Module focuses on groundwater that is part of the uppermost saturated zone on the Hanford Site, commonly referred to as the unconfined aquifer, which offers a pathway for contaminants released through the vadose zone from past, present, and future site activities to reach the accessible environment. Radioactive and hazardous chemicals have been released on the Hanford Site from a variety of sources including ponds, cribs, ditches, injection wells (referred to as reverse wells), surface spills, and tank leaks. Many of these sources have already affected the groundwater, and some may affect it in the future. Once in the groundwater, contaminants move along the pathways of least resistance, from higher to lower elevations where some contaminants may ultimately discharge into the Columbia River.

Groundwater is the water that fills the pores or cracks between grains in a layer of sediment or rock.

The goal of the Groundwater Module is to evaluate the transport of contaminants released from the vadose zone to points of regional discharge of groundwater along the Columbia River within the 1,000-year assessment period. Contaminants released to the groundwater form plumes, some of which extend from their source areas to the Columbia River. The Groundwater Module also calculates the concentrations of contaminants in the groundwater for direct use in impact and risk calculations.

Results

The initial assessment evaluated 25 different realizations of 9 different contaminants released to the aquifer system from 533 locations in a total of 225 individual groundwater flow and transport simulations. Results of the activity and mass of various contaminants considered for a simulation using the median value for each variable, discharged to the Columbia River and remaining in the aquifer from 1944 through 3050, are presented in Figure 7.1. These results indicate that releases of all contaminants, except carbon tetrachloride, peak and begin to decline before 2000 (Figure 7.1 and Table 7.1). Releases of all the

The Groundwater Module provides two types of results for use in the initial assessment:

- *Contaminant concentration levels for use in analyzing effects on individuals who directly or indirectly use groundwater.*
- *Mass flux to the Columbia River for use in analyzing human health and ecological impacts from direct or indirect use of Columbia River water.*

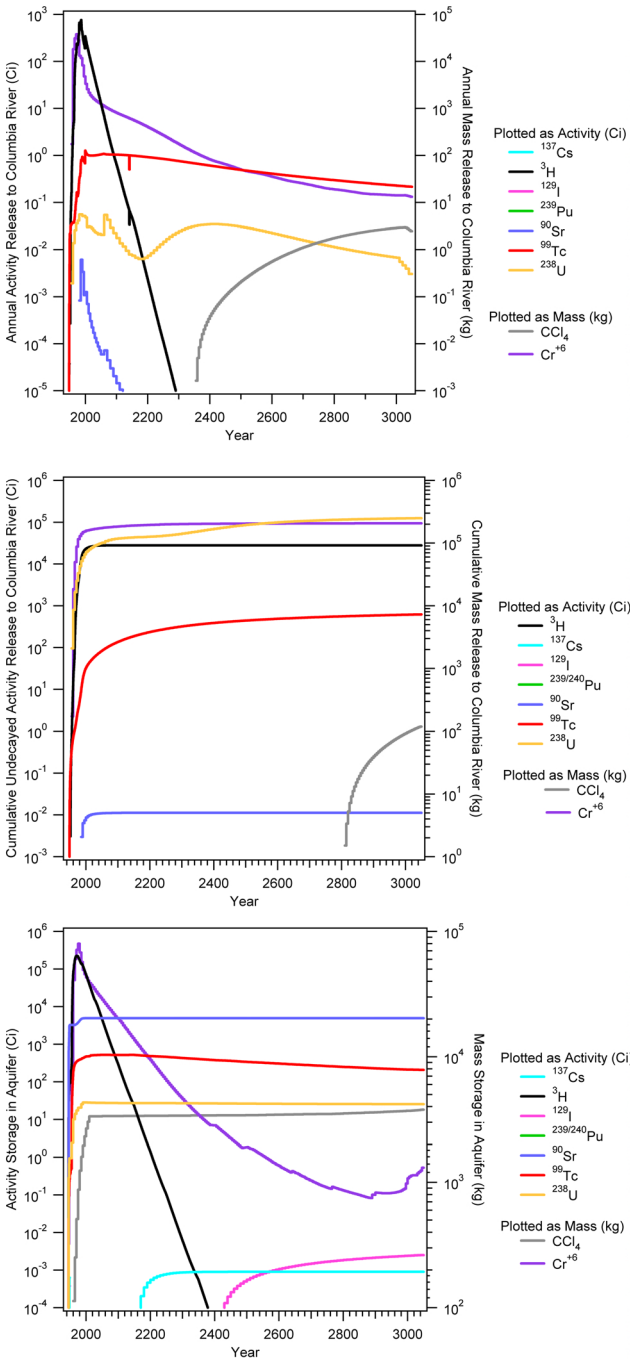

Figure 7.1. *Composite activity and mass of various contaminants from the median value run discharged to the Columbia River and remaining in the aquifer (1944 - 3050).*

radioactive contaminants decline to relatively low levels by the year 2100. Results from the median case suggest that releases of chromium, uranium, and technetium-99 from the aquifer will continue for several centuries. Secondary peaks for uranium and carbon tetrachloride occur at about 2400 and 3000 years, respectively. For all cases, simulated releases of chromium and uranium represent the largest releases, in mass, to the Columbia River. The minimum, maximum, and median activity and mass transfer from groundwater to the river for all 25 realizations for each contaminant evaluated are summarized in Table 7.2. Table 7.2 does not include direct discharges to the river from waste facilities.

The most widespread effect on water quality in the groundwater system was the development of large-scale tritium plumes. These originate from wastewater discharges containing tritium in selected operational areas in the Hanford 200 East and 200 West Areas.

The results for all 25 realizations from the initial assessment produced tritium plumes that are generally consistent with what has been observed (Figure 7.2). Large plumes exceeding drinking water standards were predicted to originate in the 200 East and West Areas. Smaller plumes exceeding drinking water standards are also predicted in 100 B/C, 100 K, 100 N, and 100 D Areas. A comparison of the extent of the modeled tritium and observed plumes above the drinking water standard is provided in Figure 7.3. Also included are comparisons for technetium-99, chromium, carbon tetrachloride, uranium-238, and strontium-90. Tritium plume concentration levels are predicted to decline steadily over the next 30 to 50 years and will reach insignificant levels between 50 and 100 years from now.

The initial assessment of iodine-129 releases produced no significant regional-scale or local-scale plumes. Field data show that iodine-129 plumes exist at levels exceeding the 1 picocurie per liter

Table 7.1. *Peak annual releases from the groundwater to the Columbia River for the median inputs case.*

Contaminant	Release Units	Peak Annual Release to River (1944-3050) Magnitude	Year
Carbon Tetrachloride	kg	2.98	3025
Chromium	kg	37,900	1970
Tritium	Ci	764	1986
Strontium-90	Ci	0.006	1985
Technetium-99	Ci	1.27	1999
Iodine-129	Ci	0	—
Cesium-137	Ci	0	—
Uranium-238	Ci	0.056	1980
Plutonium-239/240	Ci	0	—

The Groundwater Module shows that under the Central Plateau, groundwater will continue to be affected by contaminants for many years to come.

Table 7.2. *Statistics on cumulative release of contaminants to the Columbia River through the groundwater pathway at year 3050 for the initial assessment.*

Contaminant	Release Units	Cumulative Release to River at 3050[a] Minimum	Median[b]	Maximum
Carbon Tetrachloride	kg	121	121	121
Chromium	kg	115,000	207,000	537,000
Tritium	Ci	12,200	31,100	117,000
Strontium-90	Ci	0	0	0.140
Technetium-99	Ci	27.7	310	625
Iodine-129	Ci	0	0	0.513
Cesium-137	Ci	0	0	0
Uranium-238	Ci	0	1.65	9.01
Plutonium-239/240	Ci	0	0	0

(a) Accumulation of annual releases is not decay-corrected for radioactive contaminants.
(b) Median cumulative release at 3050 of the 25 realizations for the initial assessment (a median output, not to be confused with the median2 assessment that used median inputs of all stochastic inputs for a single realization).

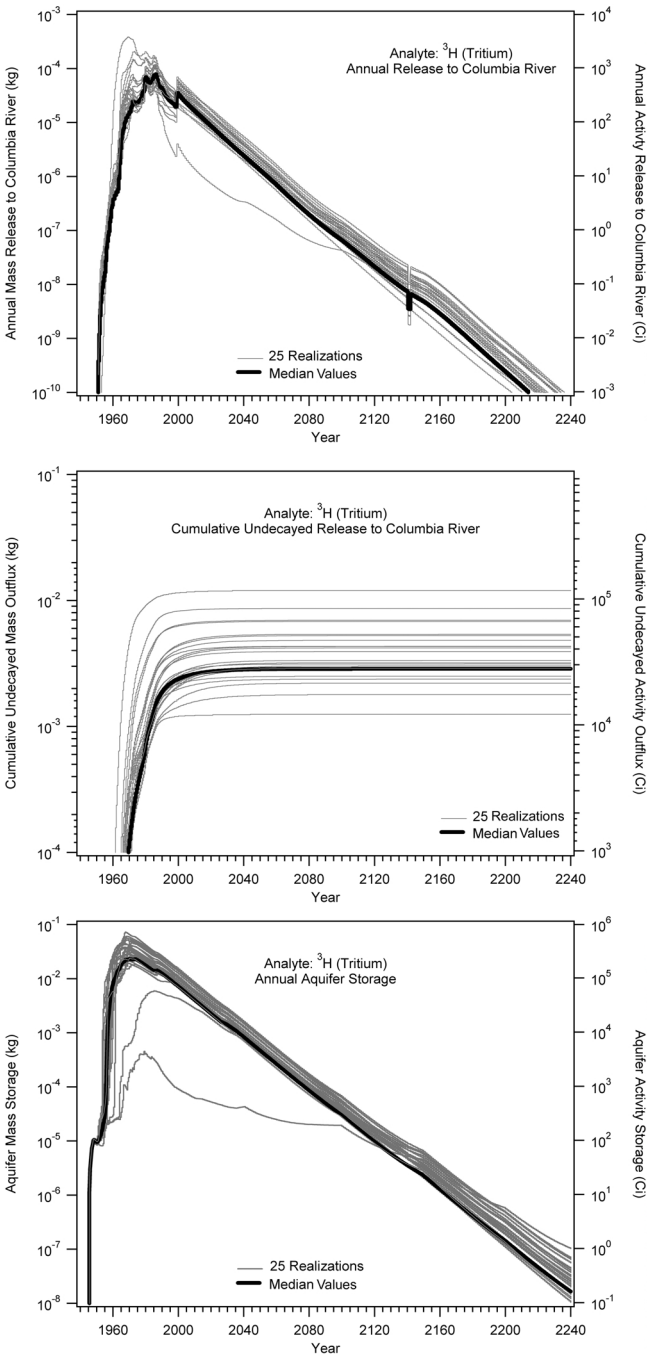

Figure 7.2. *Composite tritium values from the 25 realizations released to the groundwater, discharged to the Columbia River in the groundwater pathway, and remaining in the aquifer (1944 - 2240).*

standard in a number of operating areas at the Hanford Site. The lack of significant iodine-129 simulated concentrations and plumes in the 200 East and 200 West Areas reflects the current underestimate of iodine-129 inventory at liquid discharge sites at the BX trenches, BY cribs, and PUREX Plant in the 200 East Area, and at the T Plant, U Plant, and REDOX Plant in the 200 West Area. Current estimates of iodine-129 from these suspected source areas will need to be re-evaluated before future assessments are undertaken.

The initial assessment of technetium-99, chromium, and uranium releases produced less extensive plumes than the large-scale tritium plumes. The 25 realizations for technetium-99 produced plumes originating from liquid discharge sites at the BY cribs in the northern part of the 200 East Area and the BC cribs and trenches just south of the 200 East Area (see Figure 7.3). Simulations showed that the bulk of the discharges in the 200 East Area from the vadose zone were associated with liquid discharges to BC cribs and trenches, where releases to groundwater occurred shortly after discharges from the facility began in the late 1950s. Results for the median parameter model and the majority of the 25 realizations showed releases to groundwater continued through the 1960s and 1970s. Concentration levels of technetium-99 are predicted to decline steadily to levels below the 900-picocuries per liter drinking water standard due to dilution and dispersion as it migrates laterally to the north toward the Columbia River. Technetium-99 levels exceeding the current drinking water standards of 900 picocuries per liter were predicted to persist for the next 250 to 300 years in the 200 East Area.

The current simulation of predicted technetium-99 plumes emanating from the BC cribs and trenches and traveling northward is inconsistent with general observations and interpretations published

in the annual groundwater reports and associated RCRA groundwater assessments. Current observations in the northern portion of 200 East Area show technetium-99 plumes that appear to be centered beneath the BY cribs and adjacent areas. Significant technetium-99 releases to groundwater are not apparent beneath the BC cribs and trenches. Further work will be needed to better understand this inconsistency.

Simulation of chromium releases produced plumes originating from liquid discharge sites including the BY cribs, BX trenches, and BC cribs and trenches. Local-scale plumes of chromium that exceed drinking water standards were also predicted in the 200 West Area (S-SX tank farm) and selected operational areas within all of the 100 Areas (100 B/C, K, N, D, H, and F).

The initial assessment of uranium, carbon tetrachloride, and strontium-90 releases produced pronounced local-scale plumes in different areas of the site. Local-scale uranium plumes that exceed drinking water standards were simulated in the 300 Area in all 25 realizations. Uranium plumes that exceeded drinking water standards were predicted to occur in a few realizations near known source areas in the 200 East and West Areas (see Figure 7.3). Some of the simulated uranium plumes in the 200 East Area were estimated to persist at levels exceeding drinking water standards for 250 to 300 years.

The 25 realizations of the carbon tetrachloride releases exceeded drinking water standards close to suspected source areas in the 200 West Area near the Plutonium Finishing Plant originating from the 216-Z-9 trench, the 216-Z-1A tile field, and the 216-Z-18 crib. The 216-Z-12 crib, the 216-Z-19 ditch, and the 216-T-19 tile field are also suspected sources.

All 25 realizations of strontium release produced local-scale plumes exceeding drinking water standards in the areas of a direct aquifer injection site in the 200 East Area (B-5 reverse well) and near historical discharge facilities in the 100 N Area (see Figure 7.3). These results are generally consistent with groundwater data collected beneath the 1301-N and 1325-N facilities and at the former 216-B-5 reverse well in the northern part of the 200 East Area.

No significant groundwater concentrations of cesium-137 and plutonium-239 were produced in any of the 25 realizations except in one location where the contaminants were injected just above the aquifer. Given the affinity of these contaminants to be sorbed to Hanford soil, results for cesium-137 and/or plutonium-239 are generally consistent with what has

The groundwater conceptual model is an interpretation or working description of the characteristics and dynamics of the physical hydrogeologic system, and it consolidates Hanford Site data into a set of assumptions and concepts that can be quantitatively evaluated.

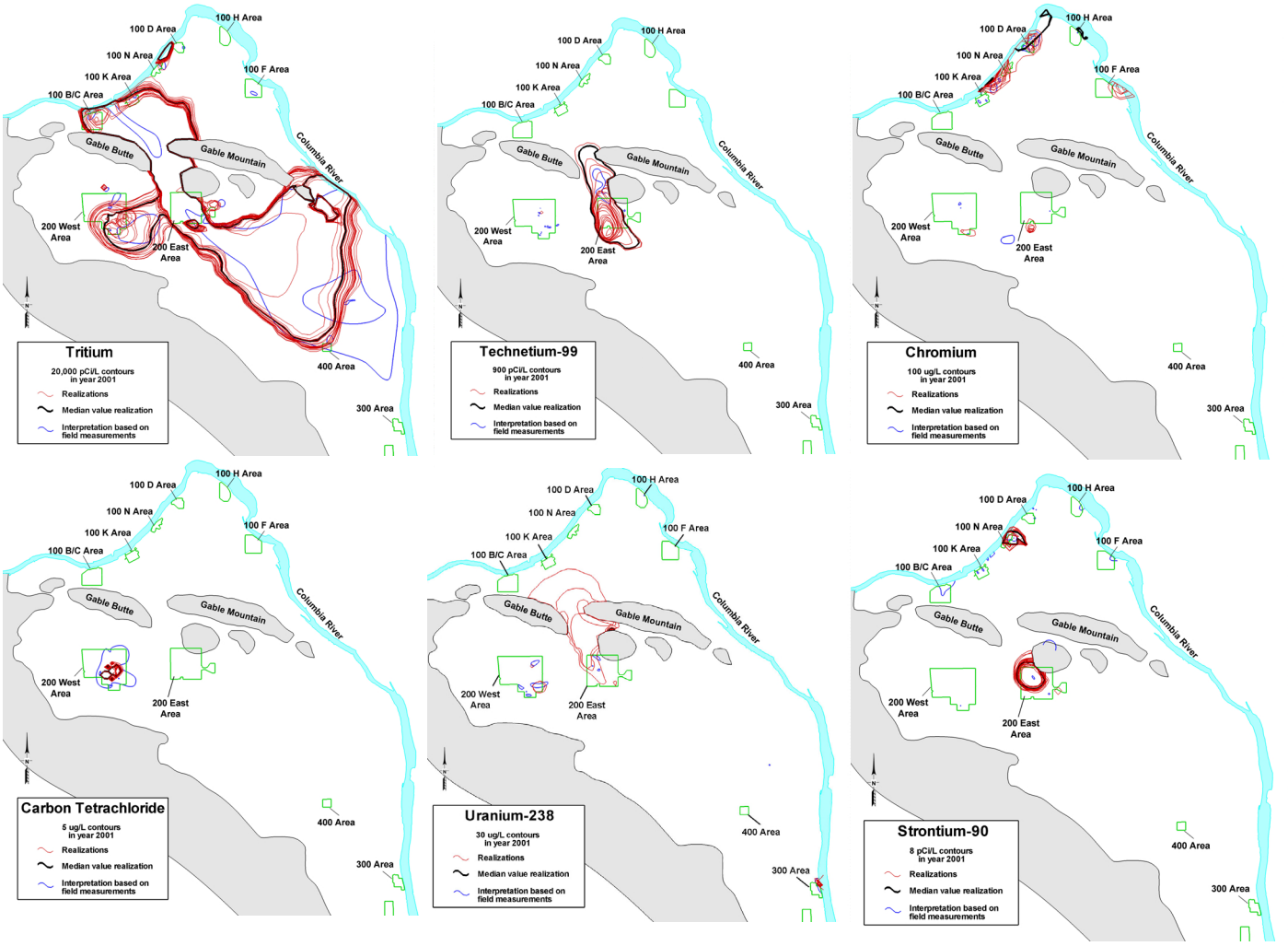

Figure 7.3. *Comparison of drinking water standard contour for the 25 realizations, median case, and field interpretations for select constituents in 2001. Where fewer than 25 realizations yielded groundwater plumes, (e.g., uranium-238), no median values are shown.*

been observed sitewide. Only one realization for cesium-137 projected the occurrence of a small local-scale plume exceeding current drinking water standards at a direct aquifer injection site (B-5 reverse well) in the 200 East Area.

Conceptual and Implementation Model

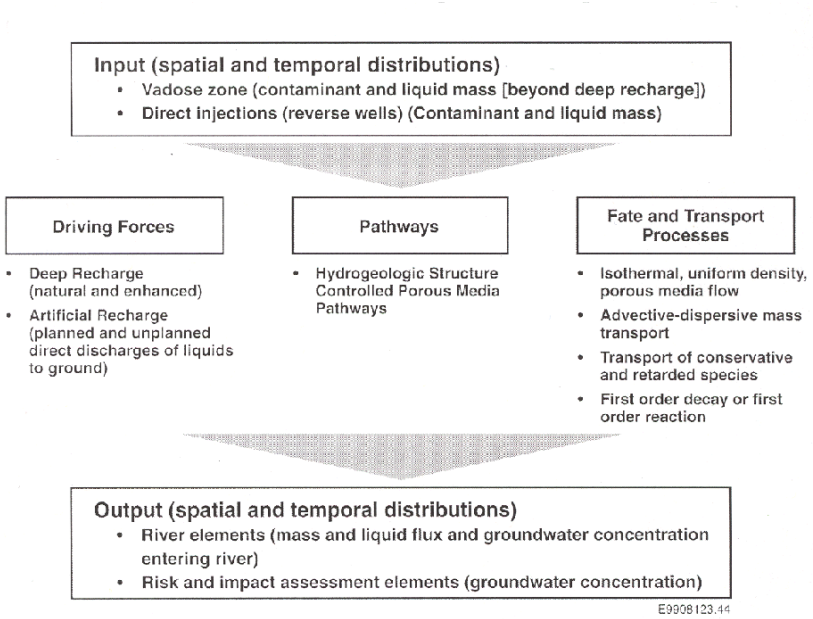

Figure 7.4. *Some primary conceptual model components for flow and transport of contaminants through groundwater.*

The state-of-knowledge concerning characterization, modeling, and monitoring of the groundwater system, described in DOE/RL (1999b), provides the primary basis for the conceptual model and numerical implementation of the Groundwater Module supporting this initial assessment. The key components needed for flow and contaminant transport through the groundwater element are schematically depicted in Figure 7.4. The groundwater conceptual model is an interpretation or working description of the characteristics and dynamics of the physical hydrogeologic system, and it consolidates Hanford Site data (e.g., geologic, hydraulic, transport, and contaminant) into a set of assumptions and concepts that can be quantitatively evaluated.

The conceptual model of the groundwater system used in this assessment is based on nine major hydrogeologic units identified in Thorne and Chamness (1992), Thorne and Newcomer (1992), and Thorne et al. (1993, 1994). Although nine hydrogeologic units were defined, only seven are found below the water table during the period of interest (Figure 7.5 and 7.6). The Hanford formation combined with the pre-Missoula gravel deposits were designated as model unit 1. Model units 2 and 3 correspond to the early Palouse soil and Plio-Pleistocene deposits, respectively. Odd-numbered Ringold model units (5, 7, and 9) are predominantly coarse-grained sediment. Even-numbered Ringold model units (4, 6, and 8) are predominantly fine-grained sediment with low permeability. The underlying basalt was designated model unit 10. However, the basalt was assigned a very low hydraulic conductivity and was essentially treated as an impermeable unit in the model.

Both natural and artificial recharges to the aquifer were incorporated in the current sitewide model. Natural recharge to the unconfined aquifer system occurs from infiltration of (1) runoff from elevated regions along the western boundary of the Hanford Site, (2) spring discharges originating from the basalt-confined aquifer system, also along the western boundary, and (3) precipitation falling across the site. Some recharge also occurs along the Yakima River in the southern portion of the site. Natural recharge from runoff and irrigation in the Cold Creek and Dry Creek located upgradient of the site also provides a source of groundwater inflow (see Figure 7.5).

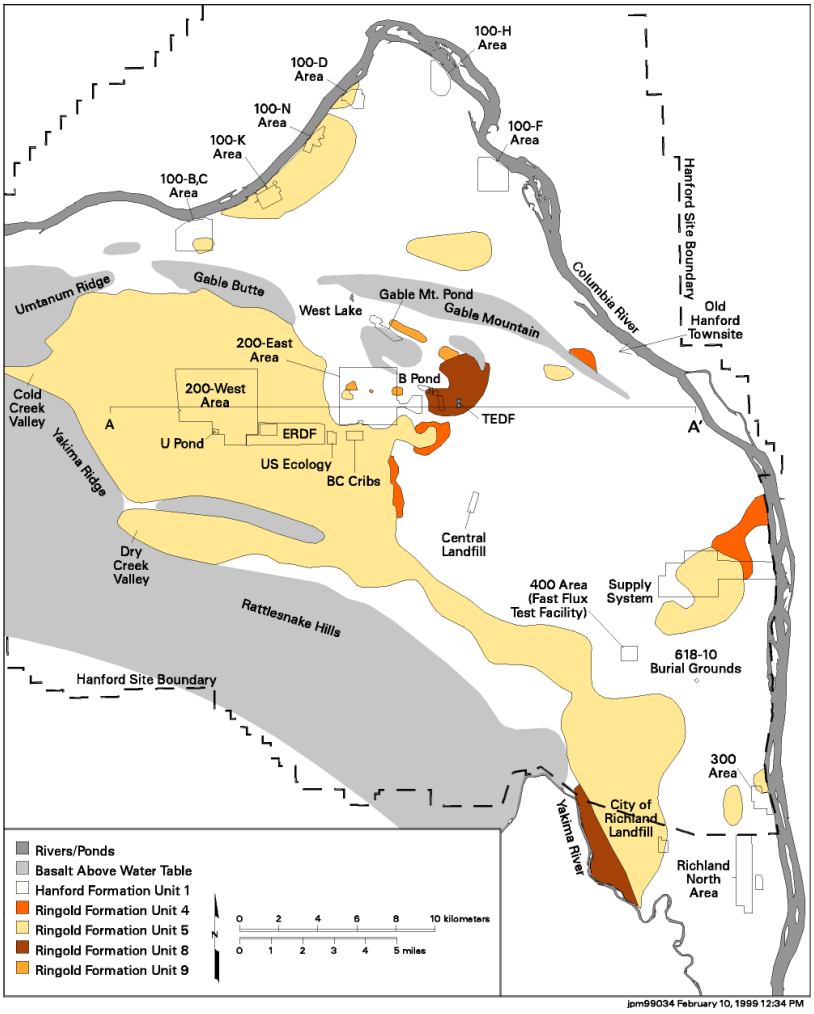

Figure 7.5. *Map of hydrogeologic units containing the water table in March 1999.*

Areal recharge from precipitation on the site is highly variable, both spatially and temporally, and depends on local climate, soil type, and vegetation. A recharge distribution applied in the assessment model is described in Cole et al. (1997 and 2001a). The general methods used to develop these recharge estimates are described in detail in Fayer and Walters (1995).

The other source of recharge to the unconfined aquifer is wastewater disposal. Large volumes of artificial recharge from wastewater discharged to disposal facilities on the Hanford Site over the past 50 years has significantly impacted groundwater flow and contaminant transport in the unconfined aquifer system. The volume of artificial recharge will decrease significantly in the near future, and the water table is expected to return to more natural conditions after site closure. A brief description of the current estimates of artificial recharge as applied in the sitewide model used in this analysis is provided in Cole et al. (2001a).

The flow system is bounded by the Columbia River on the north and east and by the Yakima River and basalt ridges on the south and west. The

Columbia River represents a point of regional discharge for the unconfined aquifer system. The amount of groundwater discharging to the river is a function of the local hydraulic gradient between the groundwater elevation adjacent to the river and the river-stage elevation. This hydraulic gradient is highly variable because the river stage is affected by releases from upstream dams. To approximate the long-term effect of the Columbia River on the unconfined aquifer system in this analysis, the sitewide model uses long-term, average river-stage elevations for the Columbia River. The river itself is represented as a constant-head boundary in the uppermost nodes of the model at the approximate locations of the river's left bank and channel midpoint. Nodes representing the thickness of the aquifer below the nodes representing mid-point of the river channel were treated as no-flow boundaries. This boundary condition is used to approximate the location of the groundwater divide that exists beneath the Columbia River where groundwater from the Hanford Site and the other side of the river discharge into the Columbia. The Yakima River was also represented as a specified-head boundary at surface nodes approximating its location. Like the Columbia River, nodes representing the thickness of the aquifer below the Yakima River channel were treated as no-flow boundaries. Additional information on the implementation of this boundary condition is provided in Cole et al. (1997 and 2001a).

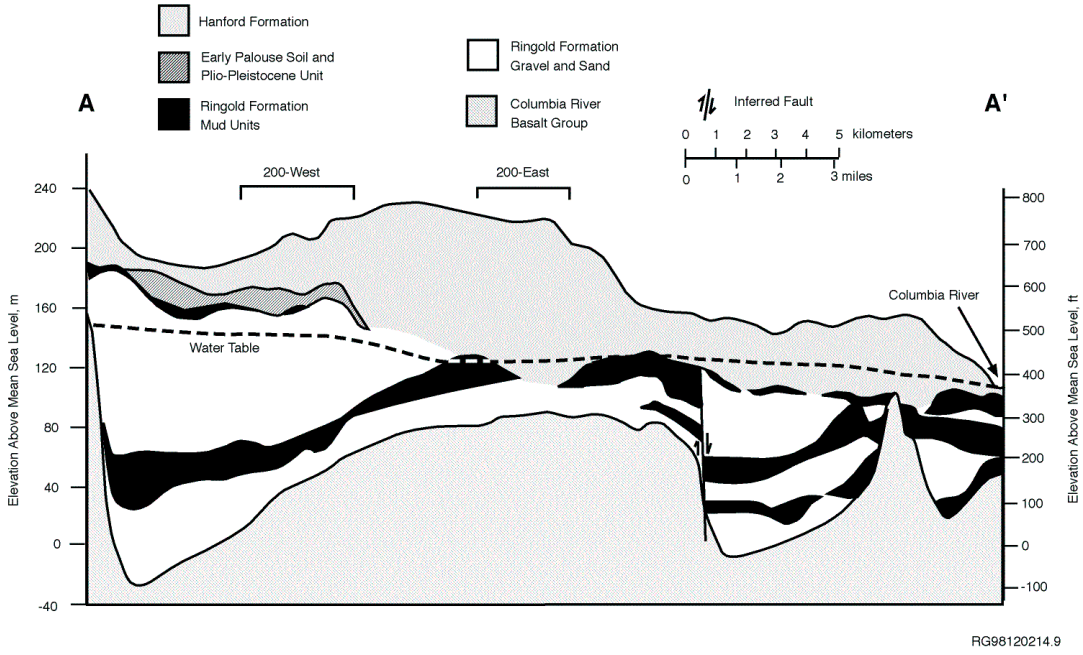

Figure 7.6. *West-East cross section showing major hydrogeologic units at the Hanford Site and the water table in 1999.*

At Cold Creek and Dry Creek Valleys, the unconfined aquifer system extends westward beyond the boundary of the model. The model used in this analysis approximate the groundwater flux entering the modeled area from these valleys with a constant-flux boundary. Specific details of the basis and rates used are described in greater detail in Cole et al. (2001a).

In addition to the influx from the vadose zone element, the groundwater model requires information that defines the physical characteristics of the hydrologic system, transport parameters, and natural and artificial recharge rates.

The basalt underlying the unconfined aquifer sediment represents a lower boundary to the unconfined aquifer system. The potential for interflow (recharge and discharge) between the basalt-confined aquifer system and the unconfined aquifer system is postulated to be small relative to the other flow components estimated for the unconfined aquifer system. An updated version of the sitewide model by Vermeul et al. (2001), which evaluated the effect of intercommunication of the unconfined aquifer with the uppermost confined basalt aquifer system, has provided some additional analysis to support this general conclusion.

For purposes of this analysis, interflow with underlying basalt units was not included in the version of the sitewide model, and the basalt was defined in the model as an essentially impermeable unit underlying the sediment.

The groundwater element takes the results of the analyses from the vadose zone technical element in the form of contaminant flux from various waste sources. In addition to the influx from the vadose zone element, the groundwater model requires information that defines the physical characteristics of the hydrologic system, transport parameters, and natural and artificial recharge rates. Driving forces, including natural recharge from precipitation and artificial recharge from waste disposal activities, contribute to the movement of the contaminants through the vadose zone and into the groundwater of the unconfined aquifer. Several important fate and transport processes, including advection and dispersion, first order radioactive decay, thermal and chemical interactions with the water and sediment, and contaminant density, may control the fate and transport of the contaminants in the groundwater. For this initial assessment, the thermal and chemical processes considered in the groundwater transport element were limited to assumptions of isothermal conditions, uniform density, and the adsorption process using the retardation factor concept.

The initial assessment focuses on the unconfined aquifer underlying the Hanford Site.

*An **unconfined aquifer** is an aquifer containing groundwater that is not confined above by relatively impermeable rocks. The pressure at the top of the unconfined aquifer is equal to that of the atmosphere. At Hanford, the unconfined aquifer is the uppermost aquifer and is most susceptible to contamination from site operations.*

The retardation factor was the only process-related parameter that was varied in the groundwater module for the initial assessment. The ranges of selected retardation factors used in the assessment were based on distribution coefficients, K_d, that reflected the chemical effect of waste types on general contaminant mobility in groundwater combined with information on average bulk densities and porosities estimated for major hydrogeologic units found in the unconfined aquifer system. The minimum, maximum, and median retardation factor values used in the 25 realizations for each contaminant evaluated are summarized in Table 7.3.

The definition of the hydrologic system is based on previous subsurface investigations that have collected data on the hydrologic units, unit boundaries, hydraulic conductivity, hydraulic heads, storativity, and specific yield. Transport parameters are based on both site-specific work of previous investigations and published literature values for parameters including effective porosity, dispersivity, contaminant-specific retardation coefficients, and vertical and horizontal anisotropy. The groundwater flow and transport model also requires estimates of natural recharge rates and locations and magnitude of artificial recharge to the hydrologic system, which are available from historic records and direct measurements. Model domain boundaries are established for the flow system based on site-specific knowledge and output data requirements. Boundaries are established along the northern and eastern portion of the site corresponding to the course of the Columbia River and along the southeastern portion of the model along the course of the Yakima River. Basalt ridgelines and the Cold Creek Valley form the western model domain boundaries. Lower flow boundaries are established between the confined basalt aquifer system and the overlying unconfined aquifer. A complete description of the groundwater conceptual model is provided in Appendix D of DOE/RL (1999b).

Table 7.3. *Range of retardation factors used in the 25 realizations and median case for contaminants investigated.*

	Retardation Factor		
Constituent	**25-Realization Minimum**	**25-Realization Maximum**	**Median Inputs Case**
Carbon Tetrachloride	1.9	3.6	2.6
Chromium	1.0	2.9	1.0
Tritium	1.0	1.0	1.0
Strontium-90	91.7	339.6	175.9
Technetium-99	1.0	1.6	1.0
Iodine-129	1.3	14.7	6.2
Cesium-137	2,690	74,030	15,090
Uranium-238	2.9	18.8	7.4
Plutonium-239	1,708	13,620	4,769

The definition of the hydrologic system is based on previous subsurface investigations that have collected data on the hydrologic units, unit boundaries, hydraulic conductivity, hydraulic heads, storativity, and specific yield.

Numerical Model

A complete description of the sitewide groundwater flow and transport model used in the current assessment is provided in Cole et al. (2001a). The current Hanford sitewide groundwater model is implemented with the Coupled Fluid, Energy, and Solute Transport (CFEST) code (Gupta et al. 1987; Cole et al. 1988), which was identified as the code of choice for the Groundwater Flow and Transport module in the initial assessment (Kincaid et al. 2000).

The sitewide groundwater model used in this assessment was recently calibrated to the historical water-table data from Hanford operations using a newly-developed calibration method. The calibration made use of ~76,000 historical water-level measurements collected from the unconfined aquifer since 1948.

Simulated flow conditions during the historical period of operations that provided the basis for all transport calculations are described in Cole et al. (2001b). These flow conditions incorporate the effect of large-volume discharges of wastewater to a variety of waste facilities since the inception of the Hanford Site in 1943. These operational discharges have raised the water table, created groundwater mounds, and been the source of local- and regional-scale contaminant plumes under waste management sites and facilities along the Columbia River and in the central part of the site. Since 1988, the mission of the Hanford Site has changed from weapons production to environmental restoration. As a result, wastewater discharges have declined significantly, which caused the water table to decline significantly over the past decade. Simulation of future water table decline indicates that the aquifer would return to more natural levels within 150 to 300 years. These results are consistent with previous work on future water-table declines described in Cole et al. (1997) and Kincaid et al. (1998).

The current approach relies on a three-dimensional representation of the aquifer system that was calibrated to Hanford sitewide groundwater monitoring data collected during Hanford Operations from 1943 to the present. The calibration procedure and results for this model are described in Cole et al. (2001a).

History Matching

Because thousands of historical data exist on tritium measured in wells since 1961, more detailed evaluations were conducted to examine how well the predictions matched measured historical conditions. Time planes for tritium are shown in Figure 7.7, that compare simulated tritium concentration based on the median parameter values with measured tritium for 1965, 1975, 1985, and 1995. Both monitoring data and simulation results show tritium plumes moving from the Central Plateau to the east and southeast as well as to the north through the gap between Gable Mountain and Gable Butte. Tritium entering the groundwater in the 200 East Area spread rapidly to the south/southeast, while tritium entering the groundwater beneath 200 West Area created localized plumes due to the lower transmissivity of the sedimentary material at the water table in that region. Both sample results and simulation show the tritium plume from 200

Tritium *is the heaviest isotope of the element hydrogen. It is produced during the fission of uranium-235. Tritium is secondarily produced from activating impurities in fuel cladding. Tritium has a half-life of approximately 12.3 years and is highly mobile in the vadose zone and groundwater. Because many tritium concentration data in groundwater have been collected over the past 30 years and tritium has been monitored in the Columbia River, tritium represents a unique opportunity to history match the model against field observations.*

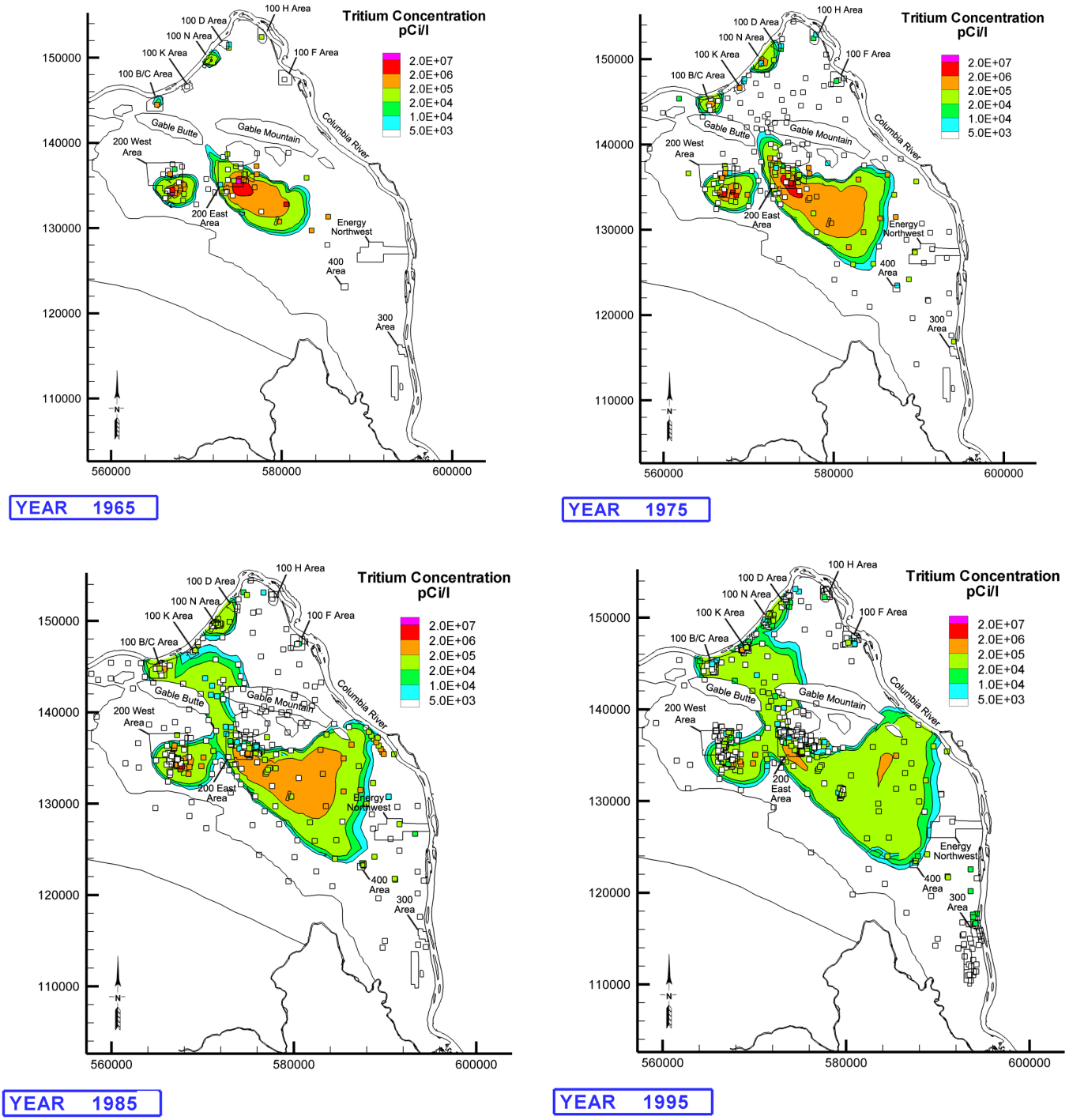

Figure 7.7. *Tritium plume, median value run with scatter diagrams of tritium values measured in wells (1965, 1975, 1985, and 1995).*

East Area reached the Columbia River to the east during the 1970s. A close examination of the results also indicate that the tritium plume originating from sources near the PUREX facility and migrating east of the 200 East Area generally tracked slower than historical observations indicated. This shows that the current distributions of hydraulic properties in this region may be too low and should be re-evaluated.

Future plans to improve the predictive capability of the sitewide groundwater model will involve calibrating the model using the historic water-level measurements and ~36,000 tritium measurements made in wells across the site since 1961.

The tritium plume originating from and migrating north of the 200 East Area from the vicinity of the PUREX Plant generally migrated farther and at higher concentrations than was observed historically. This is evidence that the constant value of about 0.07 being used in current simulations to represent the porosity in the Hanford gravels should be re-evaluated.

The center of mass of the plume originating from and migrating east of the 200 West Area tracked similarly to the historical observed center of mass but is dispersed over a broader area. Tritium plumes created in the 100 Areas are generally consistent with the location of historical tritium plumes in these areas. The concentration levels and the degree of spreading of plumes in these areas may indicate the need for a more highly resolved transport grid in the groundwater model.

Table 7.4 summarizes general observations of the initial assessment results for all the contaminants and the field evidence on existing plumes that exceed current drinking water standards. Table 7.5 provides a comparison of plume areas above drinking water standards for the year 2000, the 25 realizations, and the median case with estimated area contaminants in 1999, 2000, and 2001.

Results from the initial assessment and other ongoing work suggest that other areas of improvement should include:

- Additional resolution in the current sitewide groundwater model to better approximate the location of relevant waste sites and resulting local-scale contaminant transport behavior in operational areas along the Columbia River. This could be accomplished using the finer grid resolution in the areas of interest or by simulating flow and contaminant transport from these areas of interest in a subregional-scale model.

- Improvements in the technetium-99, iodine-129, chromium, and uranium inventories and associated releases to better approximate historical and current releases to the aquifer.

Table 7.4. *Summary of results from the initial assessment and general field observations of areas exceeding drinking water standards.*

Constituent	Modeling Predictions	Field Observations
Carbon Tetrachloride	• A local-scale carbon tetrachloride plume exceeding drinking water standards was predicted near suspected source areas in the 200 West Area in all 25 realizations.	• Carbon tetrachloride contamination is present in the unconfined aquifer system beneath most of the 200 West Area and has migrated past the 200 West Area boundaries covering an area of over 11 square kilometers. • The carbon tetrachloride contamination is believed to be from pre-1973 waste from the Plutonium Finishing Plant. • The major identified sources are the 216-Z-9 Trench, the 216-Z-1A tile field, and the 216-Z-18 crib. The 216-Z-12 crib, the 216-Z-19 ditch, and the 216-T-19 tile field also may have contributed.
Chromium	• Plumes of chromium originating from liquid discharge sites at the BX trenches, BY cribs, and BC cribs and trenches in the 200 East Area. • Local-scale plumes of chromium that exceeds drinking water standards were also predicted for the 200 West Area (S-SX tank farm) and selected operational areas within all of the 100 Areas (B/C, K, N, D, H, and F).	• Local-scale plumes of chromium that exceed drinking water standards are found in selected operational areas within many of the 100 Areas and in the 200 West Area (near T tank farm and the REDOX Plant areas) and in 200 East Area (216 cribs). • One well (299-W23-19) in the vicinity of the SX Tank Farm contains chromium that has exceeded drinking water standards. The source of this contamination is thought to originate from a past leak at tank 241-SX-115
Tritium	• Results for all 25 realizations from the initial assessment produced large-scale tritium plumes originating from the 200 East and West Areas. • Local-scale plumes exceeding drinking water standards are also predicted in 100 B/C, K, N, and D Areas. • No plume source is modeled in the 618 burial ground area.	• Large-scale tritium plumes exceeding standards originate from the 200 East and 200 West Areas. • Local-scale plumes exceeding standards are found in 100 B/C, K, N, F, and D Areas.
Strontium-90	• Local-scale strontium-90 plumes exceeding drinking water standards in the areas of a direct aquifer injection site in the 200 East Area (B-5 reverse well) and near historical discharge facilities in the 100 N Area.	• Generally consistent with groundwater data collected beneath the 1301-N and 1325-N facilities, which are contaminated with strontium-90 at levels far above the 1,000 picocuries per liter DOE-derived concentration guide. • Significant levels of strontium-90 contamination are also found at the former 216-B-5 injection well in the 200 East Area. • Very localized plumes of strontium-90 exceeding drinking water standards have also been detected near Gable Mountain Pond. • Very localized plumes of strontium-90 exceeding drinking water standards have been detected in all other 100 Areas (B/C, K, D, H, and F).

Table 7.4. *(Cont.)*

Constituent	Modeling Predictions	Field Observations
Technetium-99	• Produced plumes of technetium-99 originating from the BY cribs, BX trenches, and BC cribs and trenches of the 200 East Area. • Smaller-scale releases of technetium-99 that exceed drinking water standards were also predicted for a number of realizations for selected source areas in the 200 West Area.	• Technetium plumes exceeding drinking water standard exist in the 200 East and West Areas. • Wells with technetium-99 exceeding the drinking water standard in the 200 East Area are found in the northern portion of the 200 East Area, and north of the 200 East Area between Gable Mountain and Gable Butte. • Very localized plumes of technetium-99 exceeding the 900 picocuries per liter drinking water standard are found in the T and TX-TY tank farm and U Plant areas. • The technetium-99 plume in the U Plant area extends eastward to just outside about 1 kilometer of the 200 West Area boundary. • A developing technetium-99 plume has reached 100,000 pCi/L in the last year in wells near tank 241-SX-115, the highest technetium concentration in groundwater at Hanford since it was detected in 1985. The source of this contamination is thought to originate from a past leak at tank 241-SX-115
Iodine-129	• No significant concentrations of iodine-129 were produced in the initial assessment.	• Contamination from iodine-129 is present throughout the B Plant area. • The highest iodine-129 concentrations (drinking water standard of 1 picocurie per liter) detected in the 200 East Area in fiscal year 2001 were near the PUREX Plant cribs. • An iodine-129 plume near T Plant in the 200 West Area coincides, generally, with the tritium plume. • A separate iodine-129 plume from the 200 West Area extends into the 600 Area to the east and coincides with the tritium plume originating near the REDOX Plant. • Iodine-129 contamination exceeding drinking water standards originating farther north near U Plant.
Cesium-137	• No significant groundwater concentrations of cesium-137 were produced except in one realization near the 216-B-5 reverse well.	• Cesium-137 has contaminated groundwater near the 216-B-5 reverse well.
Uranium	• Local-scale plumes that exceed drinking water standards were simulated in the 300 Area in all 25 realizations. • Plumes that exceeded standards were also predicted to occur in a few realizations near known source areas in the 200 East and West Areas.	• Uranium plume downgradient of the 316-5 process trenches and 316-1 process pond where wastewater containing uranium was disposed. • Detected above drinking water standards near U Plant in the 200 West Area in wells downgradient from the 216-U-1 and 216-U-2 cribs and adjacent to the 216-U-17 crib. • Uranium exceeding drinking water standards is also found in the 200 West Area near T Plant, REDOX, and the 216-S-25 crib areas and north of U Pond.
Plutonium 239/240	• No significant groundwater concentrations of plutonium-239/240 were produced in any of the 25 realizations.	• Plutonium-239/240 has contaminated groundwater near the 216-B-5 reverse well.

- Re-examination of release modeling and distribution coefficients used for uranium and carbon tetrachloride to better approximate historical and current releases to and migration in the aquifer.

- Use of additional calibrated groundwater models to examine, in part, the effect of conceptual models on plume development.

Table 7.5. *Comparison of groundwater plume areas above drinking water standards for the 25 realizations and the median case with field observations.*

Area of Contaminant Plumes at Levels Above Drinking Water Standards (square kilometers) based on field data				Simulated Areas Above Drinking Water Standards (square kilometers)		
	Year			Year 2000		
Constituent	**1999**	**2000**	**2001**	**25-Realization Minimum**	**25-Realization Maximum**	**Median Inputs Case**
Carbon Tetrachloride (5 µg/L)	11.5	9.8	9.8	0.7	3.3	1.6
Chromium (100 µg/L)	2.7	2.8	2.8	0.0	8.2	2.2
Tritium (20,000 pCi/L)	191.7	152	151.1	2.5	274.9	232.0
Strontium-90 (8 pCi/L)	2.7	2.8	2.7	0.0	2.6	1.1
Technetium-99 (900 pCi/L)	2.4	2.3	2.4	0.0	28.1	5.1
Iodine-129 (1 pCi/L)	87	89.6	79.5	0.0	0.0	0.0
Uranium-238 (20/30 µg/L)	1.9	2	1.6	0.0	33.0	0.0